THE EMPIRICAL ESTIMATES OF THE PHILIPS CURVE FOR KENYA.

BY

Temitope L.A. Leshoro

Department of Economics,
P.O. Box 392,
University of South Africa,
Pretoria, 0003.
South Africa.

Work: +27 429 4590
Mobile: +27 73 616 9503
Fax: +27 429 3433
Email: lesholat@unisa.ac.za

Abstract

Kenya had its worst economic performance from 1991 to 1993, with inflation reaching a record high of 100%. This study therefore estimates the causes of inflation in Kenya using annual data over the period 1980 to 2010. Adopting the error correction mechanism (ECM) to the New-Keynesian Philips Curve (NKPC), this study considers a number of variables such as, inflation rates, lagged inflation, money supply, discount rate (as a proxy for opportunity cost of holding money) and real output. These variables were found to have both short-run and long-run relationships with inflation rates.

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1. INTRODUCTION AND BACKGROUND

There has been a persistently high inflation rates in many African countries over the past two decades, and Kenya is one of the major countries that had its share. Kenya had its worst economic performance during 1991 to 1993, where inflation was recorded to reach a high of 100%. In the 1960s, inflation was not a policy problem although the exchange rate was fixed; inflation rate was low at an average rate of 3%. The inflation rate began to rise in the 1970s with the first oil price shocks causing balance of payments problems. This further led to the devaluations and changes in the exchange rate peg. In the mid-1970s, the expansionary fiscal and monetary policies worsened the situation and economic crisis resulted. Various policy measures, which include real exchange rate rule and interest rate adjustment, were put in place helping to reduce inflation.

Furthermore, in the 1990s, excess supply of money in circulation with increased spending caused inflation to increase and further led to implementation of real exchange rate policies. Meanwhile, due to persistently high fiscal deficit in 1992, there was an increase in money printing in order to finance the deficit and the exchange rate depreciated. In the period 1994 to 1996, price stability gradually improved and inflation declined from its high levels of 1993.

The contribution of this study is to improve upon previous studies that were carried out especially for Kenya, in terms of data extension and the ability to use recent and different econometric technique. Therefore, this study estimates the causes of inflation in Kenya by applying error correction model to the New Keynesian Phillips Curve (NKPC). The variables considered are, lagged inflation, money supply growth, discount rate (as a proxy for opportunity cost of holding money), oil price and real output growth.

The purpose of this study is thus to find whether inflation process in Kenya is backward-looking or not and if these factors have short-run or long-run effects on inflation rate. If so, are these effects significant? Error correction mechanism (ECM), which contains both the short-run and the long-run effects, was used to achieve these objectives. The real output was used as opposed to the common output gap due to various reasons. Since output gap is measured as the difference between the potential

output and the real output; and potential output cannot be directly observed from available data, it therefore has to be estimated. The various types of estimation is however prone to uncertainties and mistakes in their calculation of the potential output and hence output gap[1].

Contrary to the hybrid NKPC model which incorporates both the backward-looking and forward-looking components, this study adopts the NKPC with only the inertial effect. This is because of its practical suitability and importance affirmed in empirical studies (Kiptui, 2009; Olubusoye and Oyaromade, 2008; Galí, Gertler and López-Salido, 2001; and Galí and Gertler, 1999) despite the predominance of the forward-looking element (Maturu *et.al*, 2006; Loungani and Swagel, 2001).

Fedderke and Schaling (2005) carried out a study to analyze the relationship between price levels, unit labour cost, output gap, exchange rate as an element of supply shock and price expectations. Using annual data over the period 1960 to 1999, they used the general-to-specific method of Vector Error Correction Model (VECM). They ran two long-run relationships, namely the price equation and unit labour cost model. However, the output gap variable was not significant in the price equation.

Durevall and Ndung'u (1999) used a single equation ECM to analyze the changes in inflation in Kenya using quarterly data from 1972 to 1996. They estimated the monetary sector model, while considering domestic price level, money supply, real output and vector rates of returns, which included deposit interest rates and discount rates. They also estimated a model for the foreign exchange market including variables such as domestic price level, exchange rate, foreign prices and terms of trade. They further included the maize price inflation to capture the domestic shock. Only money supply and maize-price inflation were found to affect inflation in the short-run, while exchange rate, foreign prices and terms of trade have an effect on inflation in the long-run.

On the other hand, Maturu *et.al* (2006) analysed the applicability of the NKPC function to Kenya. They used monthly data spanning over a rather short period of

[1] For in-depth explanations of uncertainties in calculating potential output and output gap, refer to Claus *et.al* (2000) and Monetary Bulletin (2005)

1997 to 2005. Using Generalized Method of Moments (GMM) estimator, they estimated the structural hybrid open economy NKPC model. Due to the problem of small sample, some of the parameters were calibrated and the two-stage GMM gave biased estimates. They measured the level of economic activity using real marginal costs rather than using real output gap or unemployment levels, due to their inconsistencies with microeconomic theories. They found that although the forward-looking component is dominant, the backward-looking element is also evident.

In line with the models considered by Durevall and Ndung'u (1999), the same inflation models were estimated by Ocran (2007) for the case of Ghana. The considered variables are consumer price, money supply growth, exchange rate, interest rates, foreign prices and terms of trade. A significant and dominant inertia was found in the short-run, while foreign prices and terms of trade do not seem to have any effect in the short-run, but significant in the long-run. Money supply and interest rates were found to be positively related to inflation. Exchange rate affects inflation both in the short-run and the long-run.

2 METHODOLOGY AND DATA

2.1 Data Sources and Variable Description

This study uses annual time series data spanning the period 1980 to 2010. In line with various studies by Durevall and Ndung'u (1999), Ocran (2007), Diouf (2007) and Olubusoye and Oyaromade (2008) the variables considered are the rate of inflation as the dependent variable, computed from the consumer price index 2005 prices. This is explained by lagged inflation rate (to capture the backward-looking effect), which enters the short-run dynamic model, money supply growth, discount rate (as a proxy for opportunity cost of holding money), oil price and real output growth. The data was obtained from the electronic database of the International Monetary Fund (IMF).

2.2 Model Specification

This study adopts the New Keynesian Phillips Curve (NKPC) model and applying the general-to-specific method of error correction technique.

The Phillips curve model is as follows:

$$INF = f(MS,\ DCR,\ OILP,\ GDP) \qquad \{1\}$$

where INF is the rate of inflation

MS is the growth rate of money supply (% growth of M2)

DCR is discount rate (% per annum)

OILP is oil price (average price, US$)

GDP is the real GDP growth (% growth of GDP)

Positive and significant lag inflation shows the evidence of inertia forces in determining current inflation rates. Money supply and discount rate, which are part of the demand-side factor that affect inflation, are expected to be positively related to the rate of inflation. Oil price is also expected to have a positive relationship with inflation rate. However, the real GDP growth is expected to be inversely related to inflation.

2.2.1 Test of Stationarity

Stationarity of a time-series means that its mean and variance are constant over time and the null hypothesis states that the series has a unit root. This test is required in order to avoid spurious regression results.

Given: $Y_t = Y_{t-1} + U_t \qquad \{2\}$

where, U_t is a stochastic error term

Y_{t-1} is one period lag of the dependent variable

If the coefficient of Y_{t-1} is 1, then either

$$Y_t = \rho Y_{t-1} + U_t$$

or

$$\Delta Y_t = \delta Y_{t-1} + U_t \text{ where } \delta = (\rho - 1) \qquad \{3\}$$

is used to confirm the stationarity or non-stationarity of the variables

If for the coefficient of Y_{t-1}, $\rho = 1$, or $\delta = 0$, then the time-series is non-stationary, otherwise it is stationary.

2.2.2 Co-integration and Error Correction Model (ECM)

Co-integration is a linear combination of two or more time-series that have the same order of integration but are not stationary. If two or more variables are co-integrated, then it shows that there is a long-run relationship between them. The long-run relationship model is therefore shown in equation {4}.

$$INF_t = \alpha_0 + \alpha_1 MS_t + \alpha_2 DCR_t + \alpha_3 OILP_t + \alpha_4 GDP_t + \varepsilon_t \qquad \{4\}$$

The error correction model (ECM) which has the short-run coefficients is as follows:

$$\Delta INF_t = \varphi_0 \varepsilon_{t-1} + \sum_{i=0}^{m} \gamma_{1i} \Delta INF_{t-i} + \sum_{j=0}^{n} \gamma_{2j} \Delta MS_{t-j} + \sum_{k=0}^{p} \gamma_{3k} \Delta DCR_{t-k} + \sum_{l=0}^{q} \gamma_{4l} \Delta OILP_{t-l} + \sum_{r=0}^{w} \gamma_{5r} \Delta GDP_{t-r} + \mu_t \qquad \{5\}$$

where, Δ denotes the first difference of the variables

μ_t is the error term

ε_{t-1} is one period lag of the error term obtained from the co-integration model in equation {4} above.

ECM corrects for dis-equilibrium between the short-run and the long-run among the variables. The one period lag of the error term is expected to be less than zero and significant for equilibrium relationship to exist.

3 RESULTS

3.1 Stationarity and Co-integration tests

In order to avoid spurious results, the variables were tested for unit root using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Dickey-Fuller GLS (ERS) test for stationarity, and all these tests yield the same results. Money supply growth and oil price are integrated of order one, I(1). Inflation rate, discount rate and real output growth are stationary, I(0). The results of the unit root tests for all the variables are reported in Table 1[2].

[2] The result of the stationarity test for only Phillips-Perron is reported in Table 1

Table 1: Summary of unit root tests: Phillips-Perron

Variables	Levels		First difference		Conclusion
	Intercept	Trend & Intercept	Intercept	Trend & Intercept	
INF	-3.059**	-3.079*	na	na	I(0)
MS	-0.735	-2.258	-5.856***	-5.899***	I(1)
DCR	-3.018**	-5.041***	na	na	I(0)
OILP	-0.567	-1.608	-7.615***	-9.719***	I(1)
GDP	-1.493	-3.351*	na	na	I(0)

*10%; **5%; ***1%.

Co-integration test was carried out on the variables that are integrated of order one, I(1) using both the Engle-Granger co-integration test as well as the Johansen-Juselius Maximum-Likelihood test. These tests show that there is co-integration among these variables. The Engle-Granger test for co-integration was done by testing the error term obtained from the long-run equation model for unit root using the ADF and the error term was found to be stationary.

Furthermore, Johansen-Juselius Maximum-Likelihood co-integrating technique was used to check the co-integration result of Engle-Granger test. The lag length was selected using lag length selection criteria, and a lag order of 4 was indicated. Co-integration test including an intercept and no deterministic trend in the co-integration equation with a lag of 4 was performed. The results of this test are reported in Table 2.

Table 2: Johansen Co-integration tests (Money Supply, Oil Price, VAR lag = 4).

Hypothesis	Trace stat	Eigenvalue	5% critical value
None	22.09940	0.560016	15.49471**
At most 1	0.752941	0.028544	3.841466

*10%; **5%; ***1%.

The Trace Rank Test and the Maximum Eigenvalue Rank Test indicate at least one co-integrating equation at the 5 percent level of significance. This means that the null hypothesis of no co integration is thus rejected.

3.2 Error Correction Model

Since the variables are confirmed to be co-integrated, which means that there is a long-run relationship between the variables, the next step is the error-correction model (ECM) which contains the short-run coefficients.

Bearing in mind that all the variables in the ECM should be stationary and from the unit root test that was carried out, all the variables, except money supply and oil price are stationary, thus the first differences of these variables that were integrated of order one, I(1), were included in the ECM in equation {5}. The one period lag of the error term ε_{t-1}, which is a stationary residual from the co-integrating equation, was also included. This error correction term captures the adjustment toward the long run equilibrium. The parsimonious model of the ECM is shown in Table 3.

Table 3: Results of the Error Correction Model

Variables	Coefficient	t-statistic
ε_{t-1}	-0.801	-1.909**
INF_{t-1}	1.378	3.529***
INF_{t-2}	-0.361	-2.635**
ΔMS_{t-1}	-0.186	1.812*
ΔMS_{t-2}	-0.127	-1.394
DCR	0.876	7.536***
ΔDCR_{t-1}	-0.606	-2.104**
ΔDCR_{t-2}	-0.607	-3.375***
$\Delta OILP$	0.515	5.084***
$\Delta OILP_{t-3}$	0.504	3.010***
GDP	2.00	3.730***
GDP_{t-1}	-2.315	-3.236***
GDP_{t-3}	1.223	3.399***
Adj R^2 = 0.88		

*10%; **5%; ***1%.

All the explanatory variables, except the two-period lag of money supply are significant, there are however mixed conclusions about the relationships between these variables and inflation rate. Positive and significant lag inflation denotes an evidence of backward-looking inflation process and the result obtained shows a significant positive effect at one year lag and a significant negative effect at two years lag. This means that there is an evidence of a backward-looking inflation process in Kenya within a one-period lag, after which inflation is not backward-looking. There is therefore some evidence of inertia in Kenyan inflation process, where a percentage increase in past inflation leads to over 1.3 per cent increase in the present inflation.

Furthermore, positive and significant money supply implies that increase in money supply increases inflation. The result shows a positive but insignificant effect of excess money supply on inflation rate in the short-run[3]. However, the effect of past excess money supply on inflation rate is negative and is weakly significant in the one-period lag. There is a positive and highly significant relationship between discount rate and inflation rate in the short-run, where a percentage increase in discount rate (the opportunity cost of holding money) causes about 0.9 percent increase in inflation rate.

Oil price also has the expected sign of a positive and significant relationship with inflation rate in the short-run up to the third lag, where a cent increase in oil price will lead to over 0.5 percent increase in inflation rate. The negative effect of GDP growth on inflation rate is not evident in the current period, except at the one period lag where a percentage increase in GDP growth in the previous year will lead to over 2 per cent fall in inflation rate in the current period.

The coefficient of the one-period lag of the error correction term ε_{t-1} is negative and quite significant. This coefficient shows that about 80 percent of the discrepancy is corrected for in each year. The adjusted R^2 of 88 percent shows a good fit of the model. Furthermore, the results of the diagnostic tests namely, normality, heteroscedasticity, autocorrelation and misspecification, which were carried out on

[3] The current money supply was dropped from the model due to its insignificance and it distorts the result.

the ECM, are reported in Table 4. The result shows that the ECM is therefore reliable since none of the null hypothesis of the diagnostic tests was rejected.

Table 4: Diagnostic tests of the ECM model

Test	stat	P-value	Conclusion
Jarque-Bera	2.016	0.364	Normality of residuals
Breusch-Godfrey Serial Correlation LM Test	0.321	0.505	No autocorrelation
ARCH	0.390	0.519	No Heteroskedasticity
Ramsey RESET	0.062	0.807	No misspecification

4. CONCLUSION

The purpose of this study is to adopt the New-Keynesian Phillips Curve (NKPC) for the case of Kenya and examine whether Kenyan inflationary process is backward-looking. Also, the aim of the study is to estimate the effects of money supply, discount rate as a measure of the opportunity cost of holding money, oil price, and real GDP growth on inflation rate, including the lag of inflation to capture inertia which enters the error correction model (ECM). The effects are further classified as either short-run or long-run. The error correction mechanism was used to achieve these objectives.

This study estimates the effect of the above variables on inflation in Kenya using annual data over 1980 to 2010. The unit root test was carried out on all the included variables, and all the variables were stationary, I(0), except money supply growth and oil price, which were found to be I(1). Co-integration test was carried out on the variables that are integrated of order one, I(1), using both the Engle-Granger co-integration test and Johansen-Juselius Maximum-Likelihood test. These tests show that there is co-integration among these variables; hence the null hypothesis of no co-integration is rejected. This means that there is a long-run relationship among all the variables considered.

Long-run effects of money supply growth, discount rate, oil price and growth rate of real GDP on inflation rate was found. Not only do these variables affect inflation in

the long-run, they also have significant effects on inflation rate. Since lagged inflation enters the short-run dynamic model, this variable does not have any long-run effect on current inflation process. However, all the explanatory variables, along with the lagged inflation were estimated to find whether there exists any short-run relationship with inflation rate. The backward-looking component shows a significant effect on the current inflation only in the one-period lag; the result shows a significant evidence of inertia.

There was no direct significant link between increased money printing and inflation rate in Kenya in the short-run. Although there is a positive effect, the result shows an insignificant positive effect on inflation rate. There are positive and significant effects of discount rate and oil price on inflation rate in the short-run. GDP growth has a positive and significant effect on inflation rate in the current period, but GDP growth in the previous year has a negative and significant effect on current inflation rate.

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